

## Microelectronics and Microsystems Microfabrication Technologies

# Solar Glitter! Microsystem-Enabled Photovoltaics

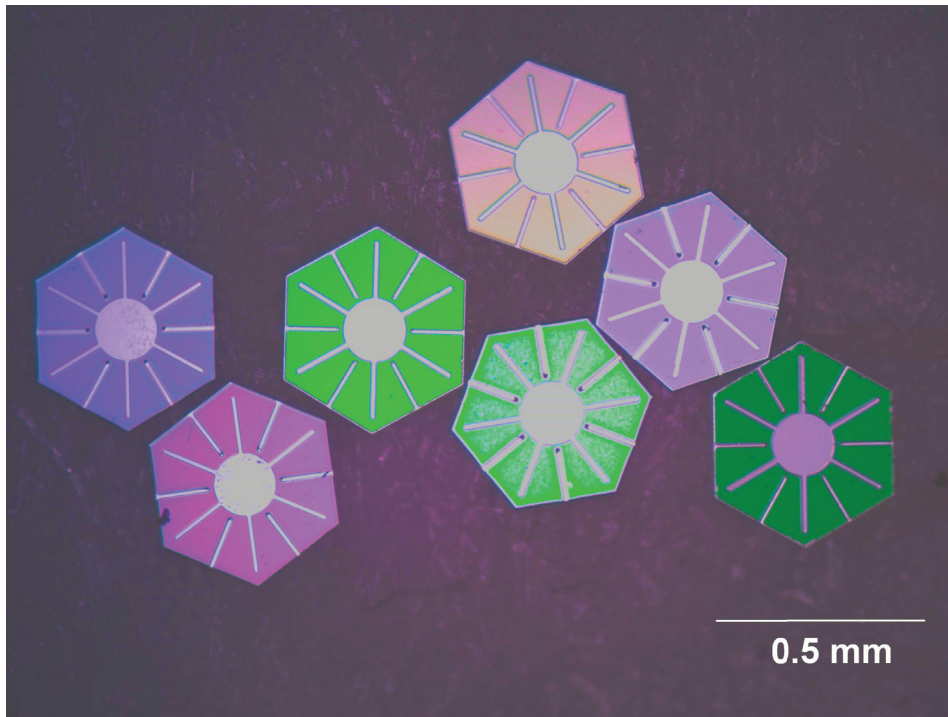


Figure 1: Crystalline silicon "Solar Glitter" cells.

*Tiny solar cells offer  
technical, efficiency, and  
cost advantages over  
conventional systems*

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**S**olar power is the most likely energy source to provide the next great energy revolution. Solar power is clean, does not emit greenhouse gases, is by far the most abundant energy source available (it exceeds all fossil, nuclear, and other renewable sources combined), and is widely distributed around the planet. However, solar power is currently too expensive to be a broadly competitive energy source. Researchers at Sandia are developing a new approach to solar power that takes advantage of microsystem concepts and technologies in order to reduce the cost of materials used for photovoltaic (PV) solar power conversion, improve the performance of these systems, and enable new functionality that is currently not available in solar power. Together, these benefits have the potential to reduce the cost of solar power significantly.

The key enabling technology for this approach to PV is the ability to create, through microsystems technology, very small solar cells made from high-quality crystalline silicon or gallium arsenide semiconductor materials. The cells are so small that, when released from their wafers, they take on the appearance of glitter. Figure 1 is an optical microscope image of representative "Solar Glitter" cells manufactured at Sandia. The cells in Figure 1 are 20 microns thick, 500 microns across, and composed of crystalline silicon. Efficiencies of nearly 15% have been demonstrated, with anticipated efficiencies exceeding 20% for the single junction cells.

Crystalline silicon and gallium arsenide make very good solar cells due to the high quality and performance of the material and semiconductor bandgap characteristics that are well matched to the solar spectrum.

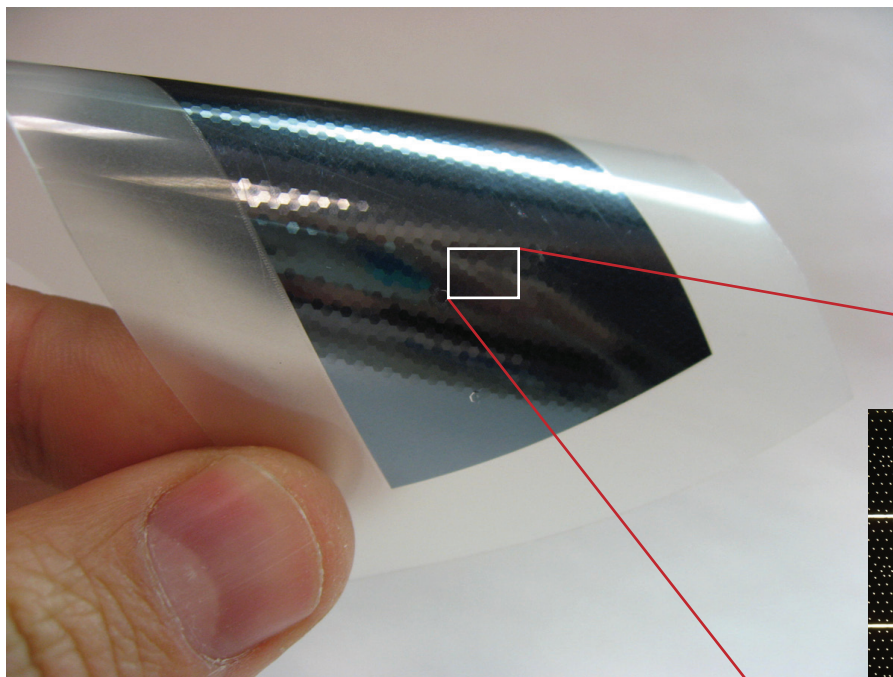
However, these high quality materials are expensive. As much as 25% of the cost of a typical solar PV system comes from the silicon material alone. The Solar Glitter cells being manufactured at Sandia reduce the amount of silicon or gallium arsenide by at least a factor of ten.

The small lateral dimensions of the cells provide additional benefits that are not possible with larger scale cells. For example, Figure 2 shows an image of a mechanical demonstration prototype of a flexible PV module comprised of the Solar Glitter cells. Traditional crystalline silicon solar cells are rigid and cannot provide this kind of flexible PV functionality. Currently, the only flexible PV modules that are available are based on low quality materials that provide a poor solar conversion efficiency of around 5%. Whereas, flexible PV based on Solar Glitter has the potential to exceed 20% conversion efficiency. This improvement in performance in flexible PV modules would be a significant benefit to mobile or remote systems or sites, with particular benefits for the warfighter.

There are many additional benefits (over twenty) resulting from the small scale of the cells, some of which are listed

here. There is a built-in ability to improve the optical efficiency through the use of concentrating optics (i.e., microlenses). The systems are able to provide more robust system performance in shading situations. There is an enhanced ability to perform optical tracking (pointing the system towards the sun) within the module, thus significantly reducing system costs such as racking, wiring, tracking, etc. High-voltage output can be derived directly from the module, thus reducing costs for wiring and/or DC/DC converters in large PV systems. A much better thermal performance of the system relative to conventional PVs improves the efficiency and extends cell lifetimes.

Given the performance improvements and direct cost reductions, these advantages of "solar glitter" have the potential to enable solar power at a cost level competitive with fossil fuel grid power, thus allowing all the benefits of solar power (clean energy, no greenhouse gas emissions, abundant and distributed power, etc.) to be economically accessible.



**Figure 2:** Mechanical demonstration of a flexible PV module based on Solar Glitter cells.

